Propeller Component Project Update

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Report Documentation Page

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24th Replacement of Hard Chrome Plating Program Review Meeting, July 20-21, 2004, Park City, UT. Sponsored by SERDP/ESTCP.

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15. SUBJECT TERMS

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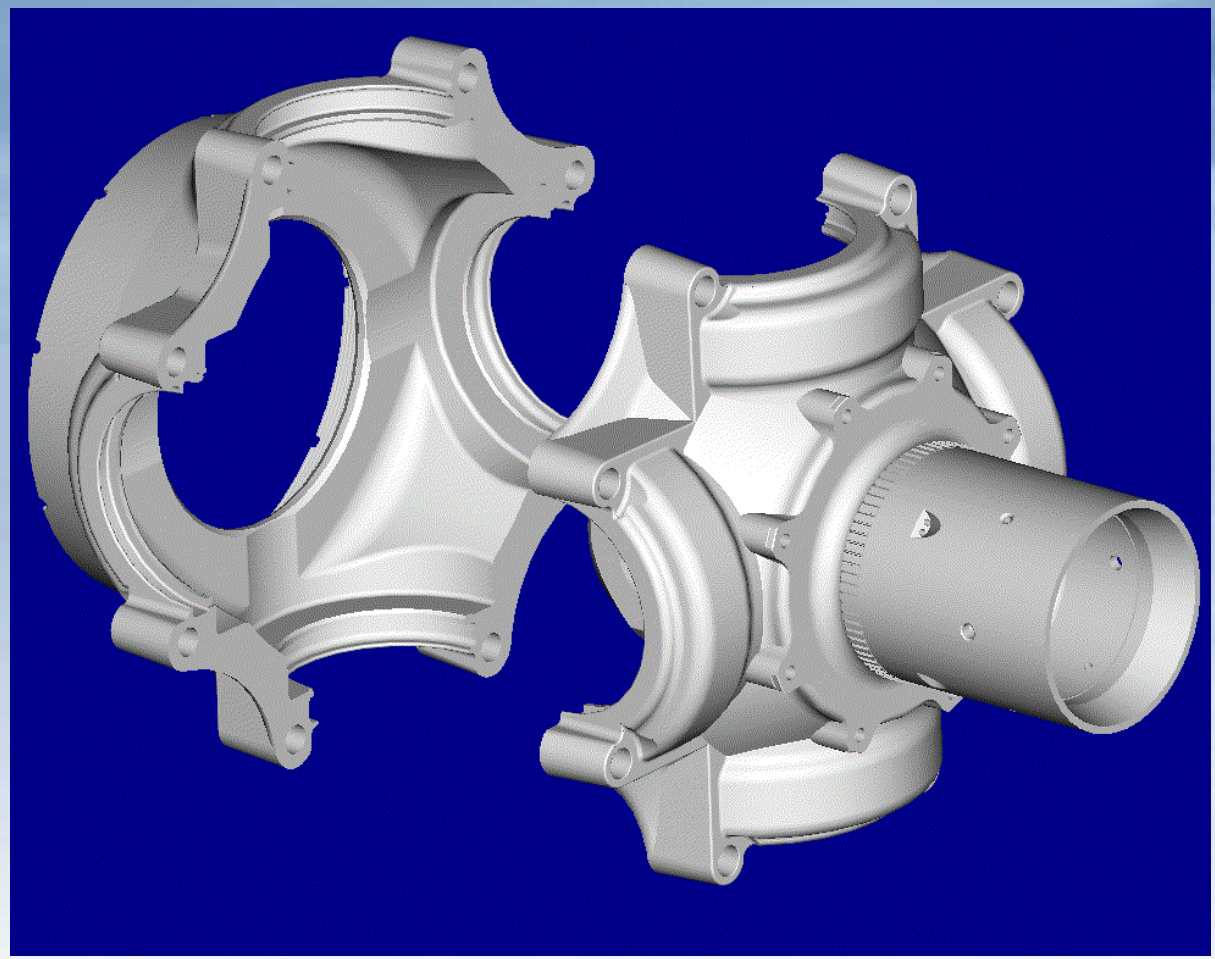
P-3/C-130
Barrel & Pin Assembly



P-3/C-130
Barrel & Pin Assembly

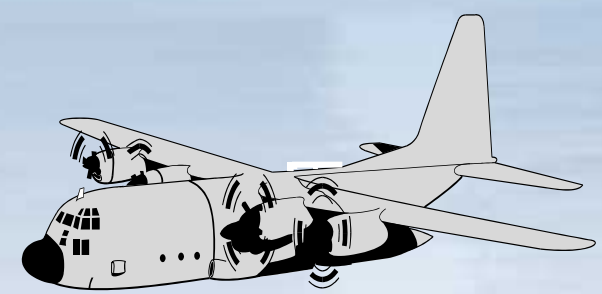
P-3/C-130
Lever Support Sleeve

Cr-Plated LPSLS

WC-Co Coated LPSLS

Implementation Efforts at Depots

- HVOF systems installed at NADEP Cherry Point
- Warner-Robins ALC installation complete
- Fixtures developed
- Grinding training
- Manual changes
- Joint process instruction



Qualification of Depots

- Process procedures will be submitted
- Each facility submits booth/procedure qualification samples
  - Metallographic samples
  - Almen coupon
  - Tensile bond buttons
  - Bend Test

- Each facility will coat a representative part or shape to be tested for residual stress in coating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HCAT Orlando Meeting

February 2002

HCAT Propeller Hub Team

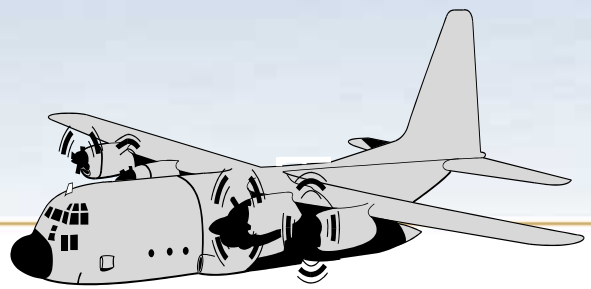
Hamilton Sundstrand, NADEP Cherry Point,
Warner Robins AFB, NADEP Jacksonville

Program Milestones

- ✓ Fatigue Testing - completed April 2001
- ✓ Wear - completed April 2001
- ✓ Corrosion - completed January 2001
- ✓ TCLP - completed January 2001
- ✓ Low Pitch Stop Lever Sleeve Component Test
  - ✓ Chrome plated - completed August 2001
  - ✓ WC-17Co - completed September 2001

Future Program Milestones

- Full Scale Engine Test of P-3 Hub at HS - Aug. 2002
- Completed Materials JTR - June 2002
- NADEP JAX based P-3 Operational Test - Nov. 2002
- Developing Joint Depot Operating Procedure - February 2003
- Operational JTR complete - November 2003



Summary Of Fatigue Tests

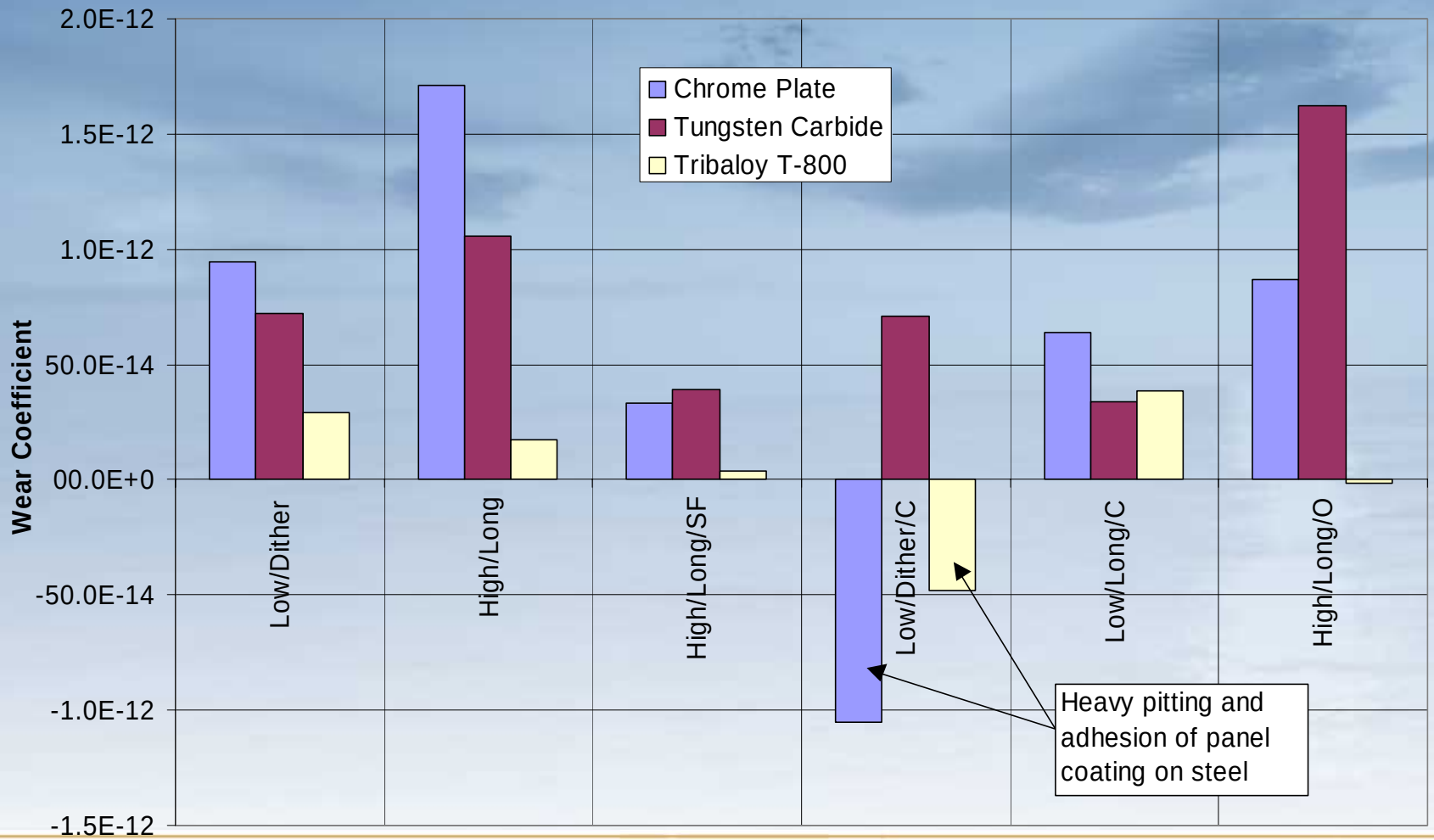
- **WC-Co exhibited a 10% reduction in strength at low cycle stresses, and a 5% reduction in strength at high cycles stresses when applied 0.010 inches thick to AISI 4340 HRC 40-44**
- **Coatings thinner than 0.010 inches exhibited less fatigue strength debit on AISI 4340 HRC 40-44**
- **WC-Co exhibit superior fatigue properties to both EHC and T-800**
- **Shot peening had a negligible effect on the fatigue strength of WC-Co and T-800**

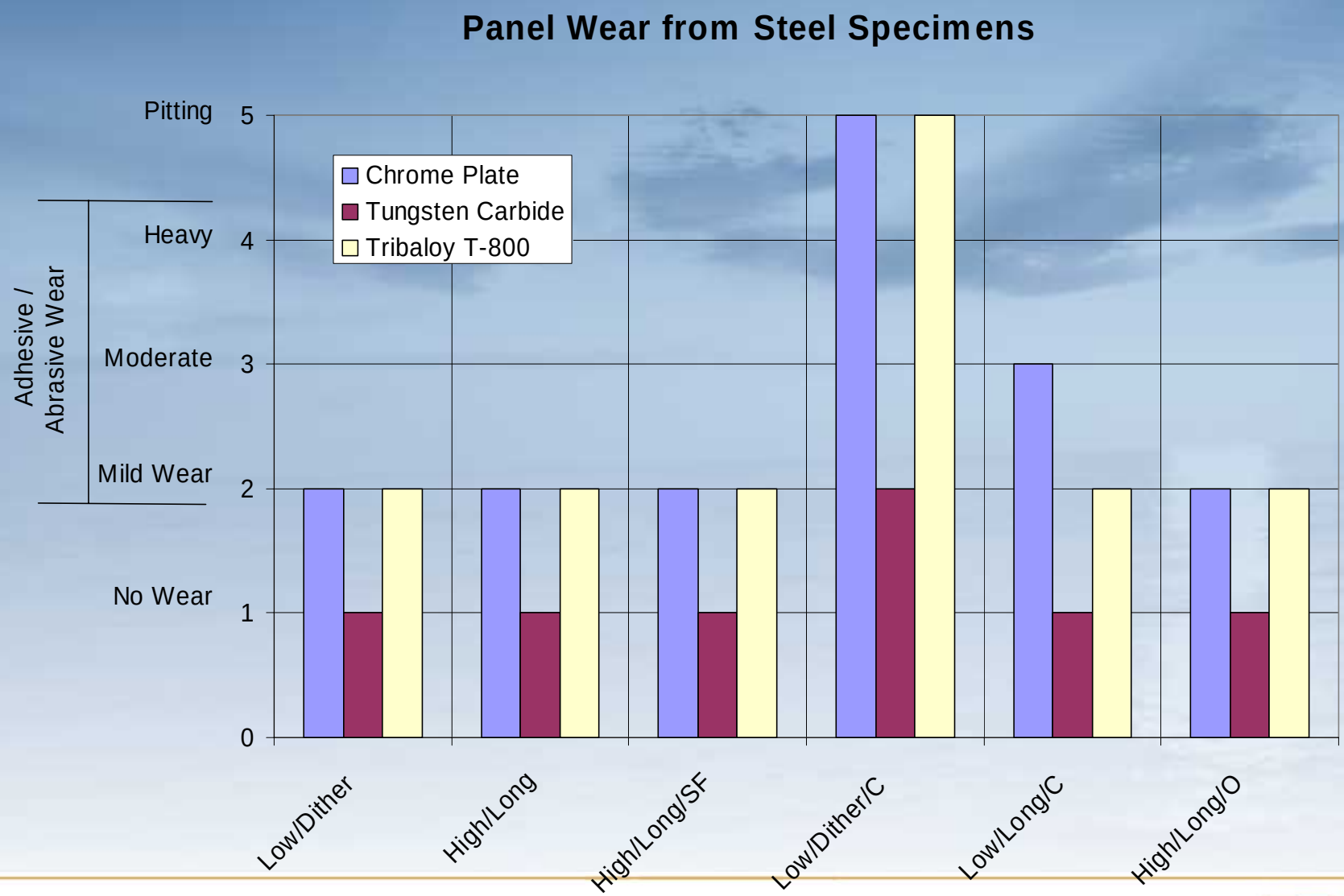
Summary of Wear Tests

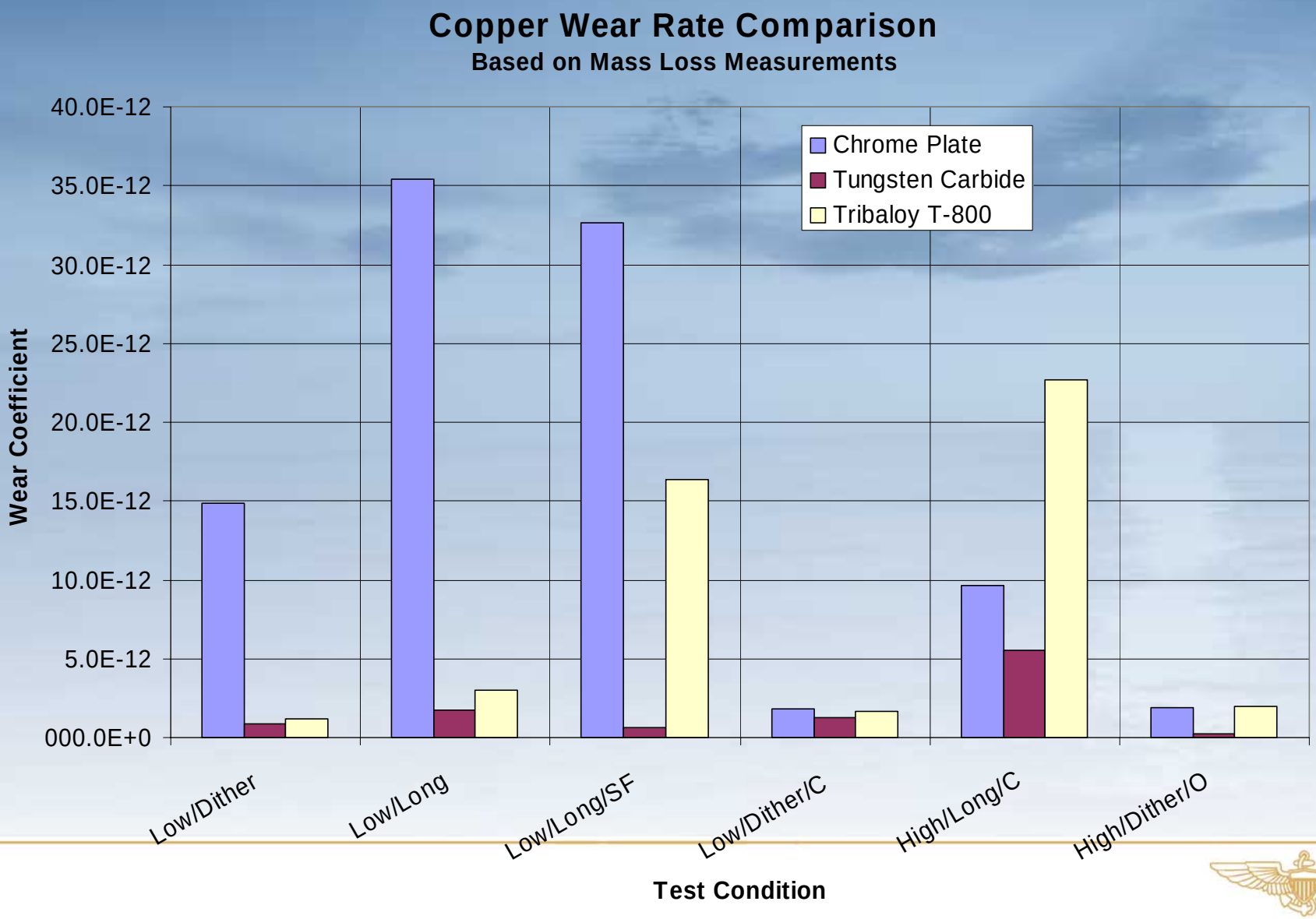
- The counterface specimen's wear performance ranking was steel, copper, then Viton based on wear coefficients
- WC-Co coating produced similar or lower wear rates on all counterface specimen materials when compared to EHC plating
- The panel specimen's wear performance ranking was WC-Co, Tribaloy T-800, then EHC plating based visual ranking of coating performance
- WC-Co-Cr coating outperformed Electrolytic Hard Nickel plating in both coating visual ranking after test and counterface wear rate

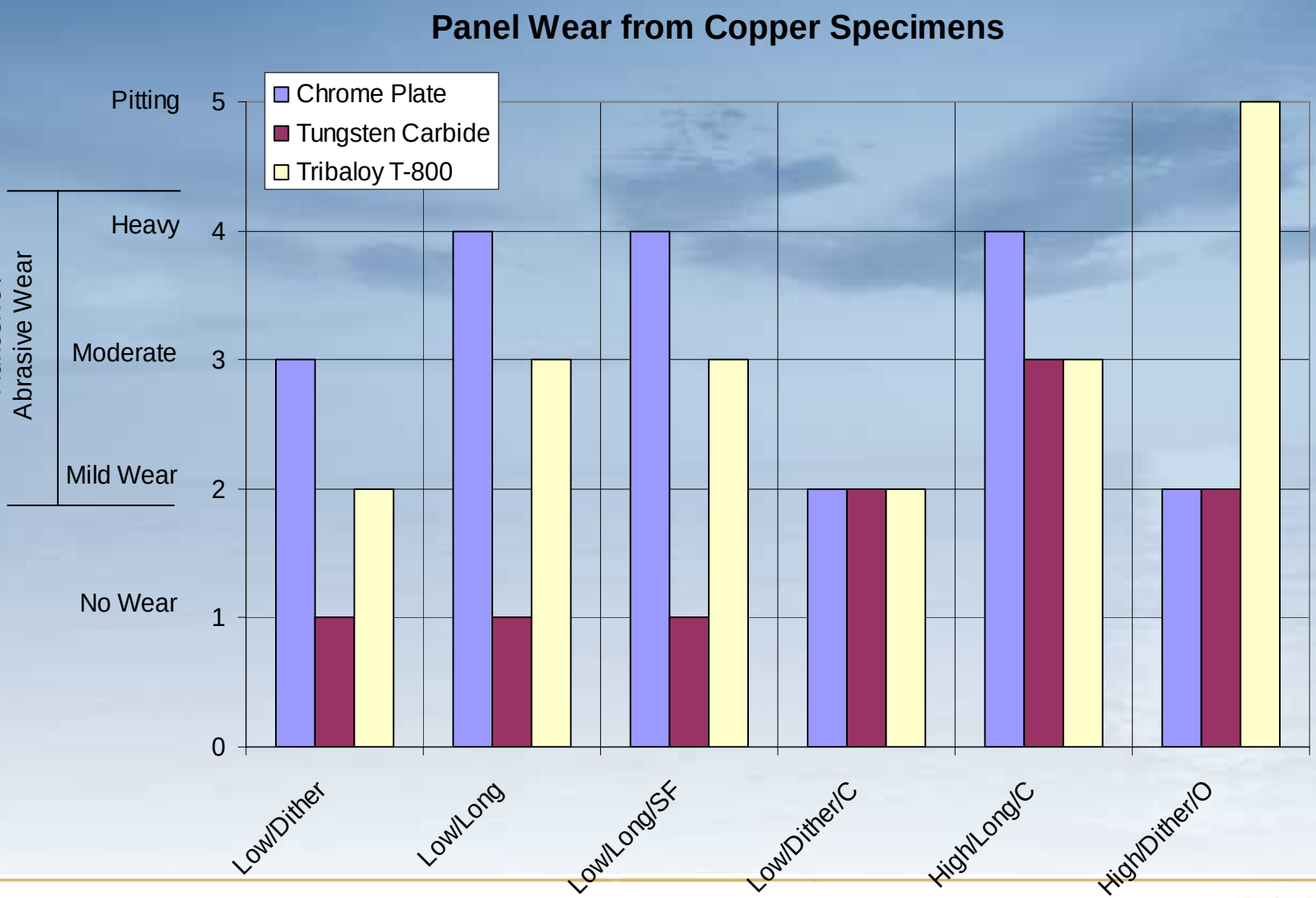
Steel Wear Rate Comparison

Based on Mass Loss Measurements



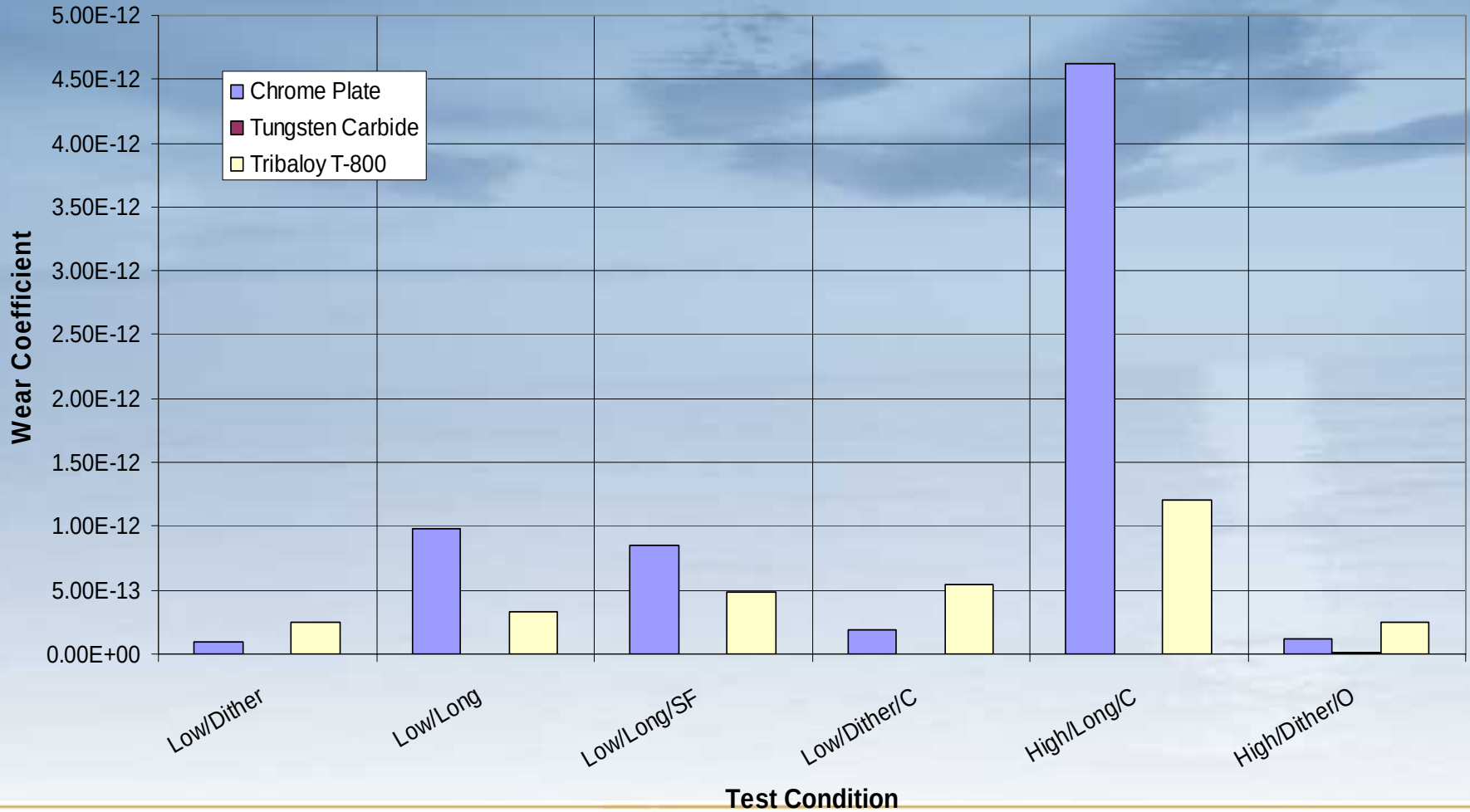

Panel Wear from Steel Specimens
Pitting
Heavy
Moderate
Mild Wear
No Wear
Adhesive / Abrasive Wear
5
4
3
2
1
0
Chrome Plate
Tungsten Carbide
Tribaloy T-800
Low/Dither
High/Long
High/Long/SF
Low/Dither/C
Low/Long/C
High/Long/O
Test Condition


Copper Wear Rate Comparison
Based on Mass Loss Measurements
Wear Coefficient
40.0E-12
35.0E-12
30.0E-12
25.0E-12
20.0E-12
15.0E-12
10.0E-12
5.0E-12
000.0E+0
Chrome Plate
Tungsten Carbide
Tribaloy T-800
Low/Dither
Low/Long
Low/Long/SF
Low/Dither/C
High/Long/C
High/Dither/O
Test Condition


Panel Wear from Copper Specimens
Chrome Plate
Tungsten Carbide
Tribaloy T-800
Pitting
Heavy
Moderate
Mild Wear
No Wear
Adhesive / Abrasive Wear
5
4
3
2
1
0
Low/Dither
Low/Long
Low/Long/SF
Low/Dither/C
High/Long/C
High/Dither/O
Test Condition

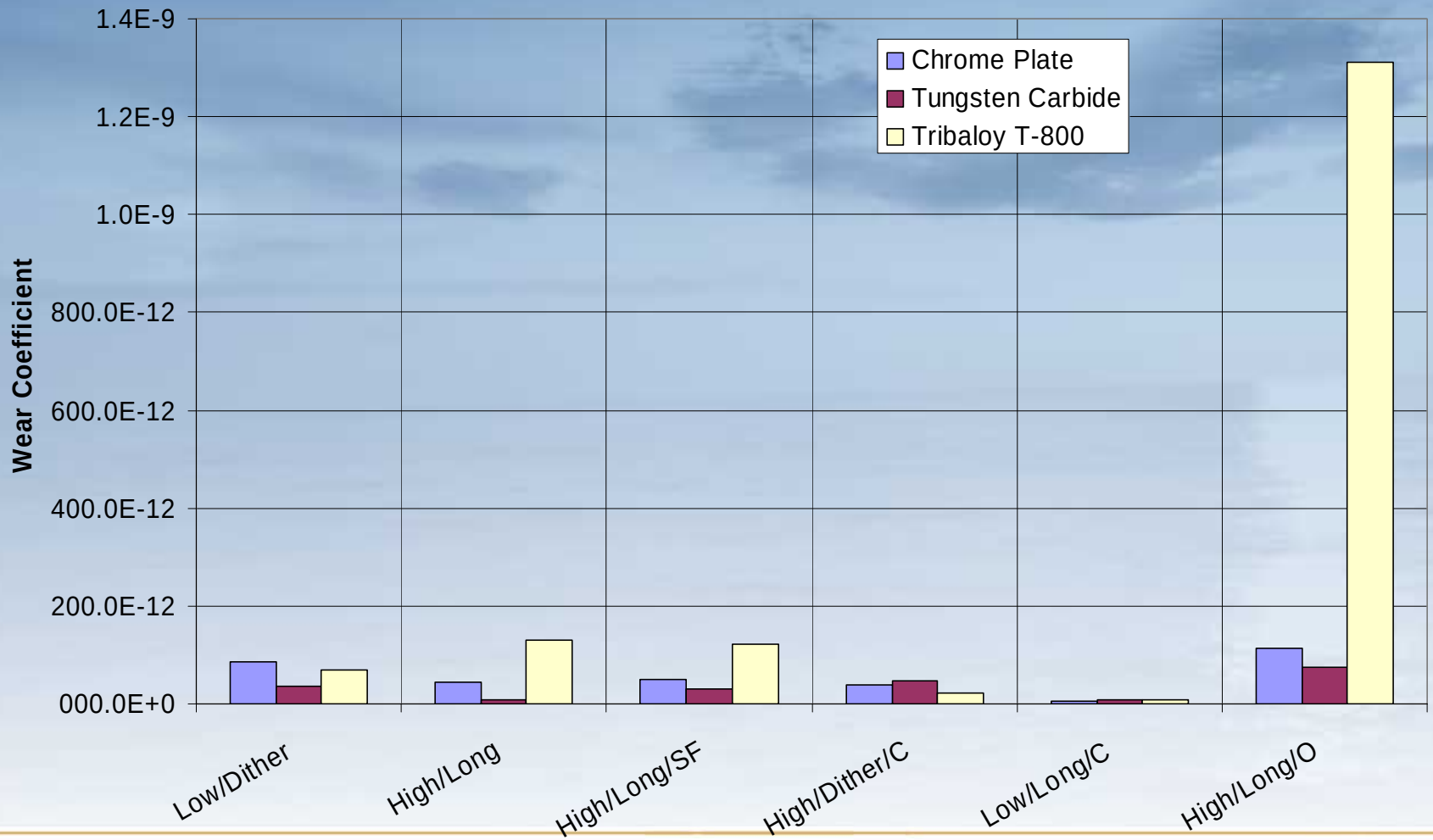
Panel Wear Rate Coefficient Against Copper Counterfaces

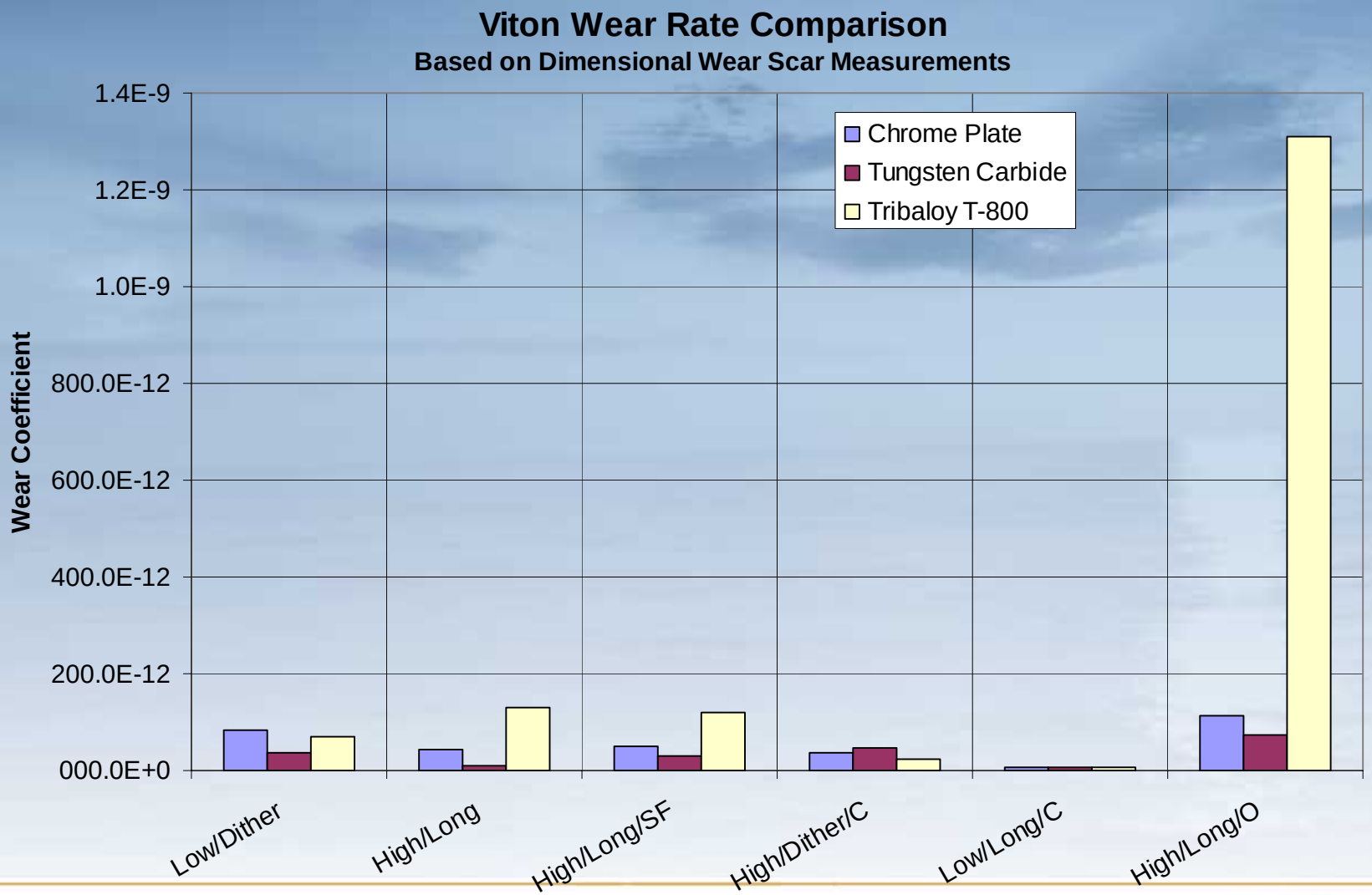
Based on Wear Scar Profilometer Measurements



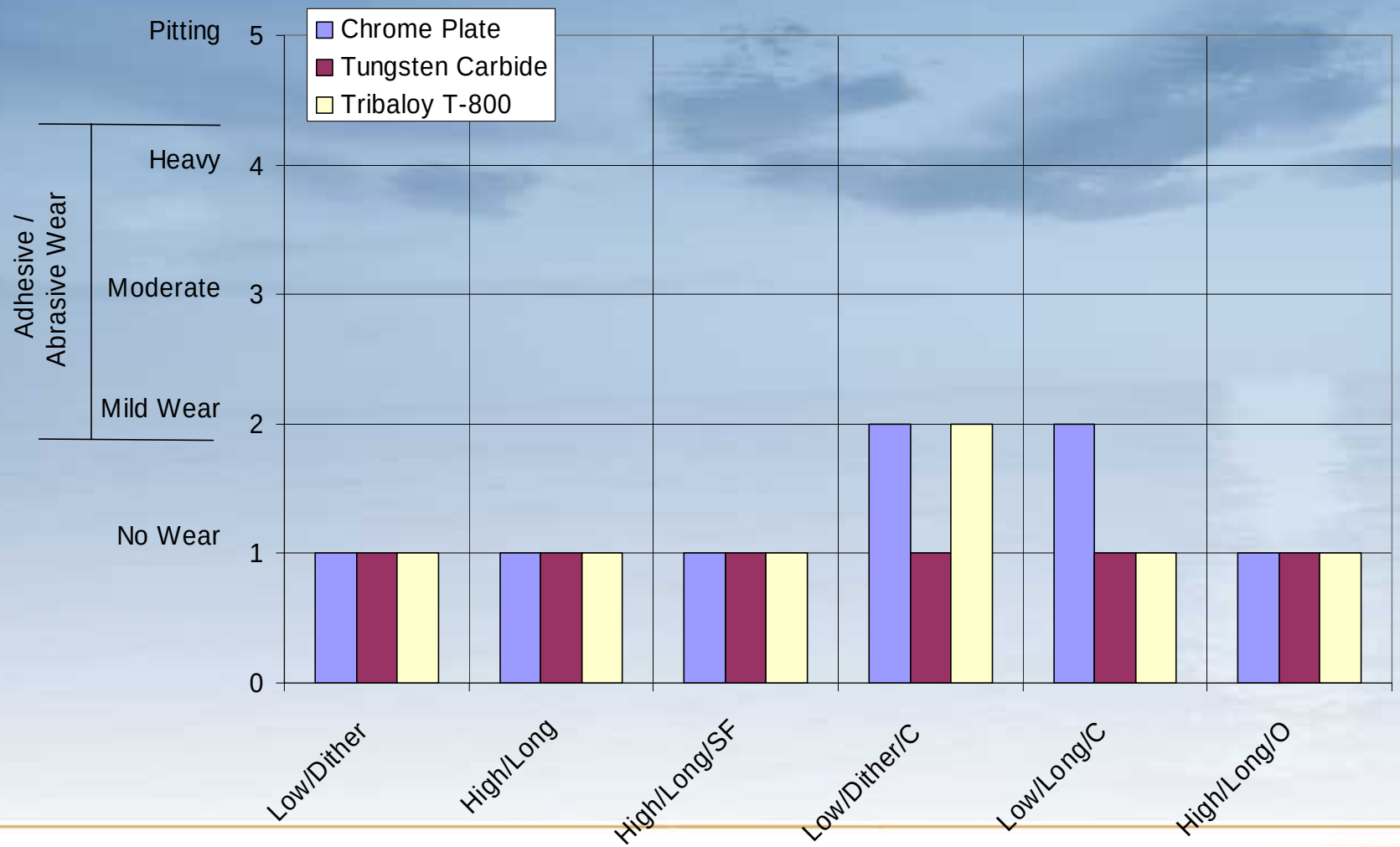
Viton Wear Rate Comparison

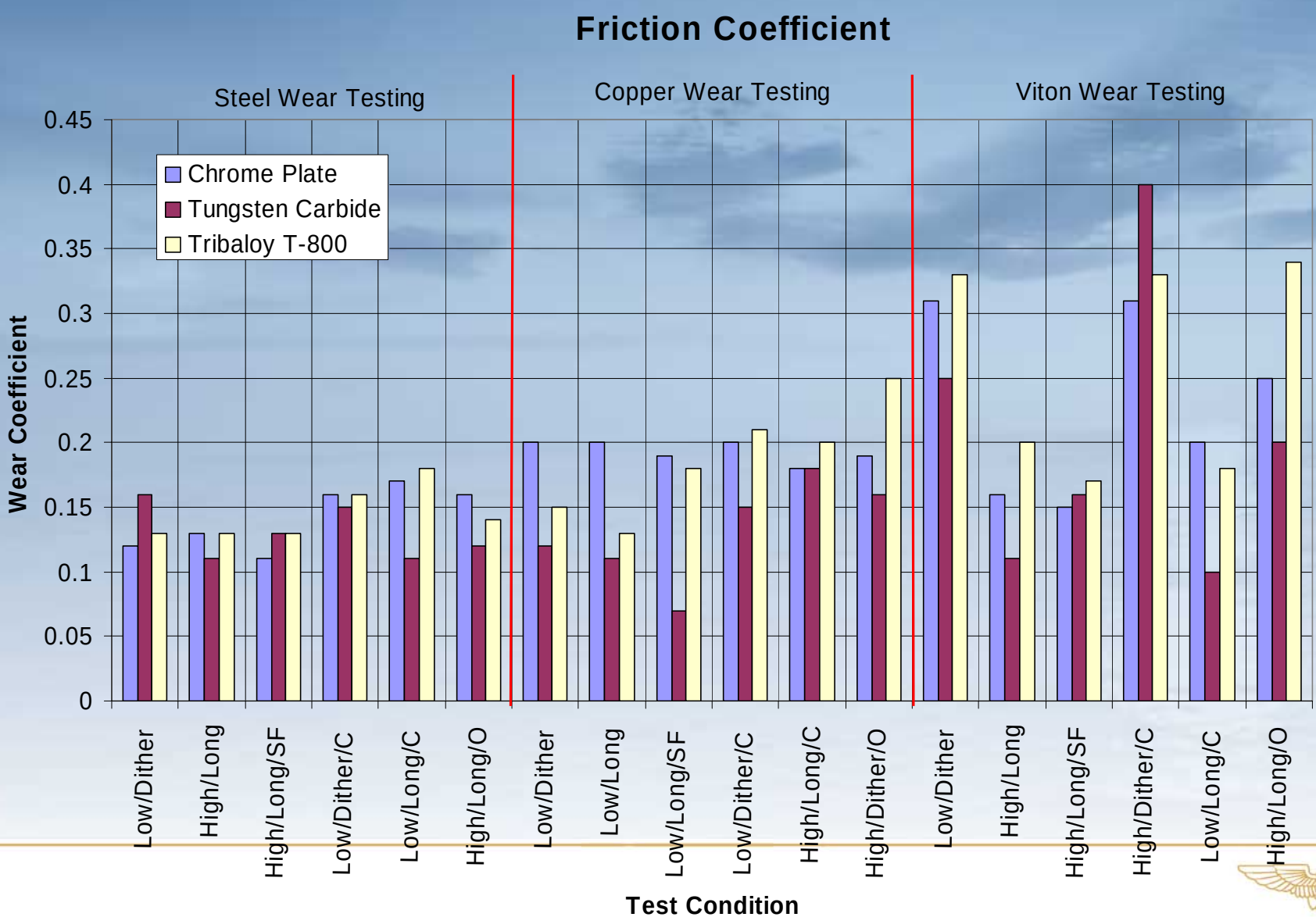
Based on Dimensional Wear Scar Measurements

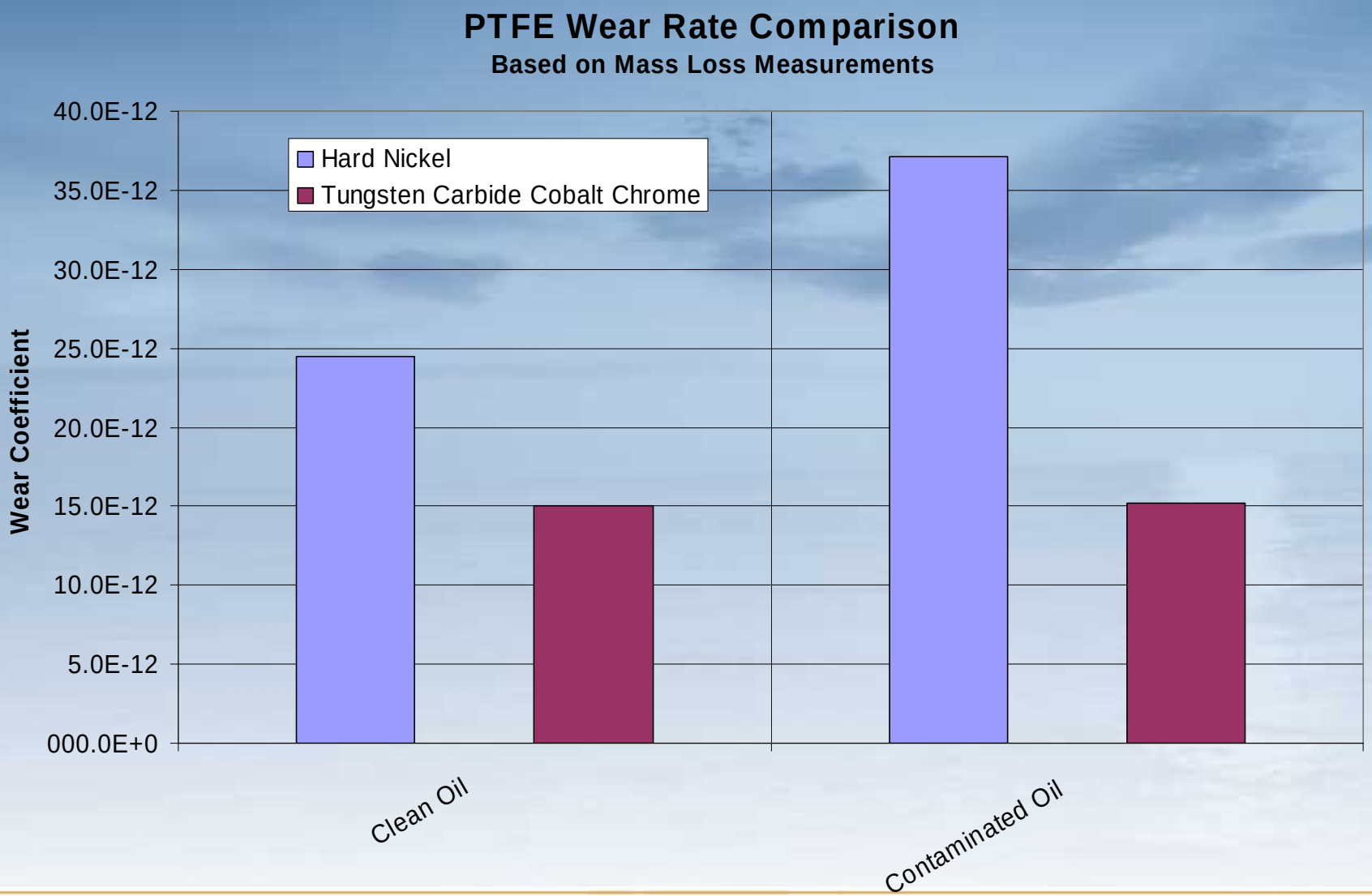



Viton Wear Rate Comparison
Based on Dimensional Wear Scar Measurements
Wear Coefficient
1.4E-9
1.2E-9
1.0E-9
800.0E-12
600.0E-12
400.0E-12
200.0E-12
000.0E+0
Chrome Plate
Tungsten Carbide
Tribaloy T-800
Low/Dither
High/Long
High/Long/SF
High/Dither/C
Low/Long/C
High/Long/O
Test Condition

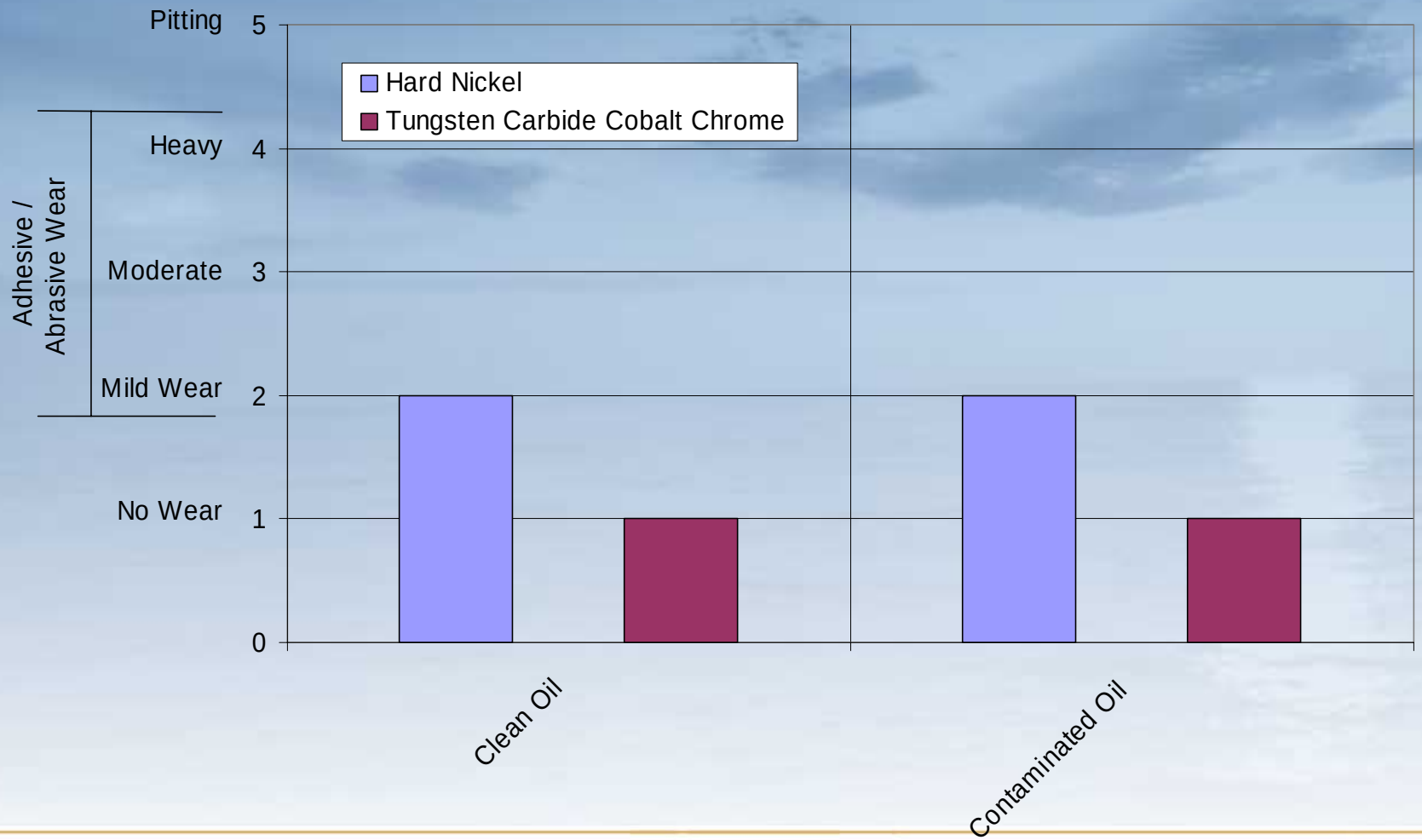
Panel Wear from Viton Specimens



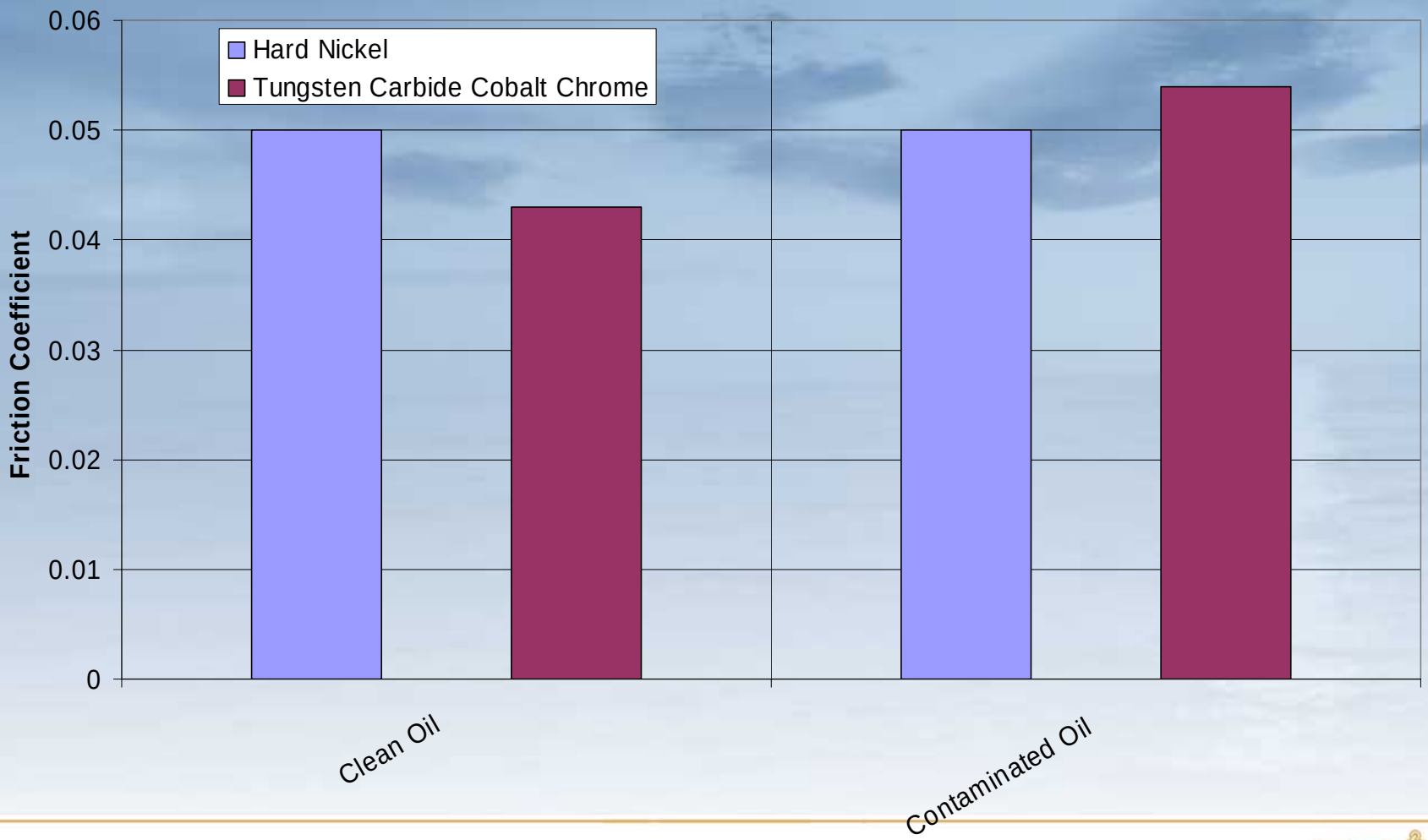

Friction Coefficient
Steel Wear Testing
Copper Wear Testing
Viton Wear Testing
Chrome Plate
Tungsten Carbide
Tribaloy T-800
Wear Coefficient
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Low/Dither
High/Long
High/Long/SF
Low/Dither/C
Low/Long/C
High/Long/O
Low/Dither
Low/Long
Low/Long/SF
Low/Dither/C
High/Long/C
High/Dither/O
Low/Dither
High/Long
High/Long/SF
High/Dither/C
Low/Long/C
High/Long/O
Test Condition


PTFE Wear Rate Comparison
Based on Mass Loss Measurements
Wear Coefficient
40.0E-12
35.0E-12
30.0E-12
25.0E-12
20.0E-12
15.0E-12
10.0E-12
5.0E-12
000.0E+0
Hard Nickel
Tungsten Carbide Cobalt Chrome
Clean Oil
Contaminated Oil
Test Condition

Panel Wear from PTFE Specimens

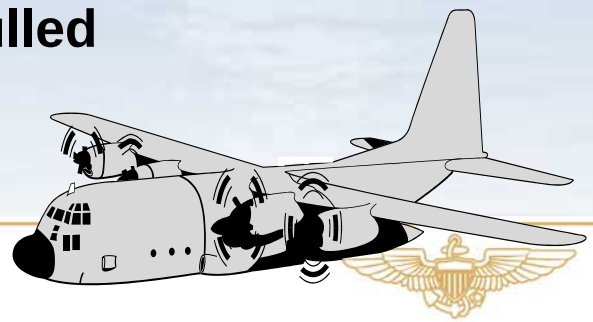


PTFE Friction Coefficient Comparison



Summary of Corrosion Tests

- Nickel Plating was the overall top performer
- WC-Co-Cr was marginally the best HVOF coating
- Quantitative results based on the # of specimens from the B117 cabinet after 552 hours
  - Criteria - visible corrosion exceeding 0.3% of area
  - 66% as coated, 100% machined WC-Co pulled
  - 55% as coated, 100% machined T-800 pulled
  - 55% as coated, 55% machined WC-Co-Cr pulled
  - 22% as coated, 25% machined Nickel pulled



Summary of TCLP Tests

- Spent Material Tested (WC-Co-Cr, T-400, T-800)
- Virgin Powder Tested (WC-Co-Cr, T-400, T-800)
- NOT HAZARDOUS WASTE
- In Connecticut Would Be Considered Non-Hazardous Regulated Waste

Low Pitch Stop Specimen

- Cylinder Coatings
  - WC-17Co
  - Chrome Plate (AMS 2406)
- Piston Ring
  - Leaded Tin Bronze
- Test Conditions
  - 75,000 Stroking Cycles = 10/flight, 1hr/flight, 7,500hrs before overhaul
  - Hydraulic oil (Mil-H-83282 or similar)
  - 310 psi oil pressure to accurate piston
  - 150°F oil temperature

Summary of Low Pitch Stop Test

- Cylinder Appearance
  - Chrome Plate - Appearance of wear on chrome plate but no significant adhesive wear or scoring
  - WC-17Co - Appears untouched
- Piston Ring Appearance
  - Chrome plate - Signs of use but no substantial wear
  - WC-17Co - Signs of use but no substantial wear

Summary of Low Pitch Stop Test

- **Quantitative Results**
  - **Cr-Plate Surface Finish 2.7 Ra at start, 1.4 Ra at completion**
  - **WC-Co Surface Finish 7.2 Ra at start, 7.2 Ra at completion**
  - **Ring weight loss 3 times higher with Cr plated bore**